REPORT OF COOPERATIVE RESEARCH ON INSECT CONTROL IN FARM STORED GRAIN

No. 12 Period--April 1 to June 30, 1944

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The material in this report consists largely of unpublished data ~~and should be kept confidential~~. It is made available in its present form for the convenience of the various State and Federal Agencies concerned with the preservation of stored grain from insect damage.

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WHEAT STORAGE

Condition of Wheat in Storage at Experimental Sites*

The regularly quarterly samples were taken from the bins at the Hutchinson, Kans., and Jamestown, N. D., experimental wheat storage projects during April and May and each sample was examined to determine the insect population. Table 1, which gives the comparison of the infestations at the Hutchinson and Jamestown sites since their establishment in 1941, shows that the insect populations at Hutchinson in April were the lowest observed since April 1943. At Jamestown the insect infestation has remained at a very low level throughout the entire storage period.

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* - Reported by H. H. Walkden and R. B. Schwitzgebel, U. S. Department of Agriculture, Bureau of Entomology and Plant Quarantine in Cooperation with the Bureau of Plant Industry, Soils and Agr. Engineering.

Table 1: -- Comparison of the insect infestation in wheat stored at Jamestown, North Dakota, and at Hutchinson, Kansas, October 1941 to May 1944.

Sampling period	Jamestown, North Dakota				Hutchinson, Kansas			
	No. bins sampled	Weevily bins (%)	Infested, not weevily (%)	Total infested (%)	No. bins sampled	Weevily bins (%)	Infested, not weevily (%)	Total infested (%)
1941								
Oct.-Nov.	139	1	18	19	144	9	31	40
1942								
Jan.-Feb.	133	1	6	7	135	16	53	69
Apr.-May	139	0	4	4	135	2	59	61
July-Aug.	142	0	6	6	124	0	43	43
Oct.-Nov.	146	0	1	1	133	58	21	79
1943								
Jan.-Feb.	152	0	0	0	144	33	21	54
Apr.-May	164	0	0.6	0.6	148	5	26	31
July-Aug.	166	0	2.5	2.5	114	60	26	86
Oct.-Nov.	132	0.8	0.8	1.6	165	46	43	89
1944								
Jan.-Feb.	165	1.3	1.3	2.6	161	6	65	71
Apr.-May	130	0.7	1.5	2.2	145	2	30	32

The five species of stored grain insects found in the quarterly samples are listed below together with their comparative abundance.

Species	Average number per 1000-gram sample
1. Flat grain beetle (Laemophloeus minutus Oliv.)...........	0.21
2. Lesser grain borer (Rhyzopertha dominica F.)............	0.13
3. Long-headed flour beetle (Latheticus oryzae Waterh.).....	0.13
4. Sawtooth grain beetle (Oryzaephilus surinamensis L.).....	0.10
5. Red flour beetle (Tribolium castaneum Hbst.).............	0.02

Distribution of Insect Populations in Stored Wheat

In order to determine the intra-bin distribution of insect populations, a separate examination of each of the individual probe samples composing the average sample has been made for each of the past four quarterly samplings.

The results of the April examinations are presented in tables 2 and 3. The data from 48 bins are included in these tables. No insects were found in samples from 96 bins and the data from one bin was omitted from the table since the infestation in that bin developed in spoiled wheat caused by a roof leak.

The intensities of infestation ranged from zero to 3.2 insects per 1000-gram sample in 1000 bushel steel bins; zero to 0.4 in 1500 bushel wood bins; and zero to 3.4 in 2740 bushel steel bins. In the 1000-2000 bushel bins 63 percent of the insects were taken in the center sample, while 25 percent were found to occur in the south portion of the grain. In 2740 to 4000 bushel bins, 46.8 percent of the population was found to be in the upper center sample and 20.7 percent was taken in the upper south sample.

A summary of the distribution of the insect populations within 1000 and 2740 bushel bins for the past four quarterly samplings is presented in tables 4 and 5 respectively.

During most of the year more than half of the insects were taken in the center and south samples in 1000 bushel bins. In August the population was well distributed throughout the grain as a result of the high summer temperatures which permeate the entire grain mass in bins of this size.

In 2740 bushel bins more than half of the insects were taken from the center and south portions of the grain each time the bins were sampled. Seventy-five percent of the time most of the insects were found in the upper half of the bins of this capacity.

The knowledge of the distribution of the insect populations within the bins for the various seasons of the year is an aid in developing an adequate sampling technique for the successful storage of grain in 1000 to 4000 bushel steel bins. It is evident from this study that samples taken in the center and south parts of the bins can be relied upon to reveal the presence of insects and indicate the maximum intensity of the infestation at any time of the year.

Table 2: -- Intensity of infestation in individual probe samples composing the 5-probe average sample from 1000, 1250 and 2000 bushel steel bins and 1500 bushel wood bins, Hutchinson, Kansas, April 1944.

Legend: * - 1250 bushel bins
** - 2000 bushel bins
*** - 1500 bushel bins

Bin No.	Location and number of insects per 1000-gram sample						
	Center	North	East	South	West	Total	Average
10-7 **	21	0	1	3	0	25	5.0
3-10	5	6	2	3	0	16	3.2
4-9	8	0	0	2	0	10	2.0
4-16	6	0	0	0	0	6	1.2
4-13	0	0	0	5	0	5	1.0
1-9	1	0	0	3	0	4	0.8
4-15 *	4	0	0	0	0	4	0.8
12-12	4	0	0	0	0	4	0.8
3-1	1	0	0	1	1	3	0.6
1-1	0	0	0	2	0	2	0.4
1-12	0	0	0	2	0	2	0.4
3-2	2	0	0	0	0	2	0.4
10-8 **	2	0	0	0	0	2	0.4
10-12	1	0	0	0	1	2	0.4
13-11 ***	2	0	0	0	0	2	0.4
½-10	0	0	0	1	0	1	0.2
1-4	1	0	0	0	0	1	0.2
1-10	0	0	0	1	0	1	0.2
1-13	0	0	0	1	0	1	0.2
2-3	1	0	0	0	0	1	0.2
2-5	1	0	0	0	0	1	0.2
2-7	1	0	0	0	0	1	0.2
3-4	1	0	0	0	0	1	0.2
3-11	0	0	0	1	0	1	0.2
4-8	0	0	1	0	0	1	0.2
13-1 ***	1	0	0	0	0	1	0.2
Totals	63	6	4	25	2	100	
Percent of total	63	6	4	25	2		

Table 3: -- Intensity of infestation in individual probe samples composing the 10-probe average sample from 2740 and 4000 bushel steel bins, Hutchinson, Kansas, April 1944.

Legend: * = 4000 bushel bins

Bin No.	Center Upper	Center Lower	North Upper	North Lower	East Upper	East Lower	South Upper	South Lower	West Upper	West Lower	Totals Upper	Totals Lower	Ave. sample
	Locations and numbers of insects per 1000 grams												
5-11*	72	9	4	0	0	0	5	0	8	0	89	9	9.8
12-1	8	0	0	0	21	0	4	0	1	0	34	0	3.4
6-8	0	0	0	0	6	0	10	0	4	0	20	0	2.0
8-9	8	0	0	0	3	1	4	0	0	0	15	1	1.6
7-4	5	0	0	0	1	0	5	0	1	1	12	1	1.3
10-5	3	0	0	0	0	0	6	0	0	0	9	0	0.9
8-5	0	1	0	0	0	0	6	0	2	0	8	1	0.9
9-6	5	0	2	0	0	0	0	0	1	0	8	0	0.8
11-2	2	0	1	0	0	0	3	0	1	0	7	0	0.7
12-7	2	0	2	0	1	0	1	0	0	0	6	0	0.6
11-5	1	1	0	0	0	0	0	0	0	0	1	1	0.2
11-9	2	0	0	0	0	0	0	0	0	0	2	0	0.2
12-2	0	0	0	0	0	0	2	0	0	0	2	0	0.2
8-4	1	0	0	0	0	0	0	1	0	0	1	1	0.2
5-2	1	0	0	0	1	0	0	0	0	0	2	0	0.2
5-1	0	1	0	0	0	0	0	0	0	0	0	1	0.1
5-8	0	0	0	0	0	0	1	0	0	0	1	0	0.1
7-7	0	0	0	0	0	0	1	0	0	0	1	0	0.1
9-3	0	0	1	0	0	0	0	0	0	0	1	0	0.1
9-4	0	0	0	0	0	0	0	0	1	0	1	0	0.1
9-7	0	0	0	0	0	0	1	0	0	0	1	0	0.1
12-8	1	0	0	0	0	0	0	0	0	0	1	0	0.1
Totals	111	12	10	0	33	1	49	1	19	1	222	15	
Per-cent of total	46.8	5.1	4.2	0	13.9	0.4	20.7	0.4	8.0	0.4	93.7	6.3	

Table 4:--Distribution of insect populations in 1000 and 2000 bushel steel bins, Hutchinson, Kansas, 1943-1944.

Date of sampling	Percent of total population taken from five locations in the bin				
	Center	North	East	South	West
Aug. 1943	30.7	16.6	19.9	17.3	15.6
Oct. 1943	21.9	11.5	13.8	32.1	20.7
Jan. 1944	10.9	8.6	3.0	71.9	5.6
Apr. 1944	63.0	6.0	4.0	25.0	2.0

Table 5:--Distribution of insect populations in 2740 and 5000 bushel steel bins, Hutchinson, Kansas, 1943-1944.

Date of sampling	Percent of total population taken in ten locations									
	Center		North		East		South		West	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Aug. 1943	23.3	8.7	9.0	3.4	9.9	4.5	16.1	9.0	10.6	5.7
Oct. 1943	25.7	17.4	6.3	3.2	9.4	2.8	17.5	6.3	9.4	2.1
Jan. 1944	18.4	26.0	1.3	0.5	0.8	0.4	17.8	28.1	4.4	2.4
Apr. 1944	46.8	5.1	4.2	0	13.9	0.4	20.7	0.4	8.0	0.4

Effect of Different Management Practices on Insect Populations in Wheat Stored in Ever-Normal Granary Type Bins

During the past quarter, winter temperatures have reduced the insect population to such a low point that differences between the various management practices is scarcely discernible. The highest populations in April occurred in the untreated bins as shown in table 6, which gives the comparison of insect infestations in wheat stored under different management practices since the establishment of the Hutchinson site.

Table 6:--Comparison of insect infestation in wheat stored under different management practices, Hutchinson, Kansas, 1941-1944.

Management practice. Steel Bins	Average number of insects per 1000-gram average sample: 1941 Oct.	1942 Jan.	Apr.	June	Oct.	1943 Jan.	Apr.	Aug.	Oct.	1944 Jan.	Apr.
Fumigation twice annually	0.6* 0.1**	T 1.7 0.5	0.3 0.4	0.4 0.6	T 0.6 0.0	0.9 0.2	0.6 0.0	0.3 0.0	T 0.1 0.0	T 0.06 0.0	0.01 0.0
Turn, clean, and fumigate in September							0.4 0.2	9.4 0.1	T 0.2 0.0	0.3 0.1	0.1 0.0
White walls and roof	0.0 0.0	1.0 0.5	0.0 0.0	0.0 0.0	1.0 1.5	0.2 0.0	0.0 0.0	1.1 0.0	2.2 0.3	0.7 0.0	0.2 0.0
White and grouped for shading							0.9 0.0	2.1 0.0	3.3 0.0	3.7 0.0	0.0 0.0
White and surface insulation							0.0 0.0	0.9 0.0	4.5 0.0	1.4 0.0	0.0 0.0
Surface insulation							0.0 0.0	24.5 0.3	16.5 0.3	8.7 0.0	1.6 0.0
Fumigation in August					4.2 1.5	1.6 0.2	2.0 0.0	T 0.5 0.1	3.3 2.3	1.8 0.0	0.6 0.0
Fumigation in September					0.3 0.3	0.7 0.0	0.3 0.0	12.5 5.1	T 0.6 0.2	0.5 0.0	0.2 0.0
Fumigation in October								18.0 1.9	T 0.9 0.2	1.1 0.1	1.0 0.0

(continued)

Table 6 (continued)

Management practice. Steel bins	1941 Oct.	1942 Jan.	1942 Apr.	1942 June	1942 Oct.	1943 Jan.	1943 Apr.	1943 Aug.	1943 Oct.	1944 Jan.	1944 Apr.
	Average number of insects per 1000-gram average sample										
Turning in January		T 1.4 0.5	1.6 0.0	0.5 0.0	9.4 1.4	T 19.0 24.0	1.2 2.2	12.5 0.1	13.2 3.0	T 5.7 6.5	0.5 0.0
No treatment:											0.0
9-10% moisture								0.0 0.0	0.2 0.0	0.0 0.0	0.0 0.0
10-11% moisture	0.2 0.0	0.2 0.0	0.2 0.0	0.1 0.0	2.2 0.4	2.8 0.4	1.0 0.0	4.5 0.4	4.7 2.7	0.6 0.4	0.1 0.0
11-12% moisture	4.8 48.7	6.6 1.2	1.5 0.5	0.0 0.0	11.5 3.9	7.6 0.7	1.5 0.1	19.8 0.6	17.8 4.4	1.9 0.6	1.6 0.1
12-12½% moisture									7.0 0.9	2.0 0.2	0.6 0.0
12½-14% moisture ***									18.5 84.8	38.5 8.6	0.2 0.0
Turn and clean when necessary						T 5.4 0.5	0.1 0.0	18.9 1.7	T 8.3 9.7	(Terminated)	
Surface oil spray		T 0.4 0.0	0.5 0.1	T -- --	T 12.5 1.7	0.2 0.0	0.4 0.0	T -- --	T 8.5 9.0	(Terminated)	

(continued)

Table 6 (continued)

Management Practice. Wooden bins	: 1941 Oct.	1942 Jan.	Apr.	June	Oct.	1943 Jan.	Apr.	Aug.	Oct.	1944 Jan.	Apr.
	Average number of insects per 1000-gram average sample										
White walls and roof						0.0	0.0	1.8	0.9	0.5	0.0
						0.0	0.0	0.0	0.0	0.0	0.0
White walls						0.0	0.0	1.5	3.6	1.1	0.1
						0.0	0.0	0.7	0.4	0.0	0.0
Red walls						0.0	0.0	6.5	8.4	2.2	0.0
						0.0	0.0	1.0	3.5	0.0	0.0

* = Bran bugs: all species except the weevils.

** = Weevils: includes lesser grain borer, rice weevil, and granary weevil.

*** = Wheat stored in ventilated bins.

T = Designated treatment applied.

Winter Mortality of Insect Populations in Wheat Stored in Ever-Normal Granary Type Bins

Mortality in the Natural Populations.

Two methods have been employed to study the effect of winter temperatures on the populations of stored grain insects in ever-normal granary type bins. In the first study a series of five 1000-bushel steel bins and eight 2740-bushel steel bins were sampled monthly from October 1943, to April 1944, inclusive. The data from these samples are presented in table 7. The mortality rate was highest in the unpainted 2740-bushel bins. The wheat in these two bins was of less than 11 percent moisture content while that of the wheat in the other 11 bins ranged between 11 and 12 percent.

It may be noted from table 7 that the insect mortality was least in unpainted 1000-bushel bins, as compared with that in the other bins under observation. The lesser grain borer, which has been the most serious pest to stored grain at this site, survived the winter near the south wall in these two unpainted 1000-bushel bins but was not found to be present in any of the other three groups of bins after the January sampling. It may also be noted from table 7 that during the sampling period the lesser grain borer population in white 1000-bushel bins remained very low and none were able to maintain themselves in white 2740-bushel bins.

Table 7: -- Winter mortality of insect populations in wheat stored in steel bins, Hutchinson, Kansas, October 1943 to April 1944.

Bushel Capacity	Color	No. Bins	Average number insects per 1000-gram sample per bin: October BB	October W	November BB	November W	December BB	December W	January BB	January W	February BB	February W	March BB	March W	April BB	April W
1000	Unpainted	2	12.8	3.0	11.1	2.5	8.6	2.0	4.6	1.6	5.8	0.7	5.3	0.4	1.6	0.1
1000	White	3	2.2	0.4	1.1	1.3	0.5	0.1	0.4	0.0	0.9	0.0	0.7	0.0	0.0	0.0
2740	Unpainted	2	12.8	3.3	7.3	4.0	2.5	0.8	0.7	0.6	0.3	0.0	0.6	0.0	0.0	0.0
2740	White	6	3.0	0.1	1.5	0.0	5.5	0.0	2.8	0.0	0.8	0.0	1.3	0.0	0.1	0.0
			Percent mortality based on Oct. 1943 population													
1000	Unpainted	2	0	0	13	17	33	33	64	47	55	77	59	87	87	97
1000	White	3	0	0	50	0	77	75	82	100	60	100	68	100	100	100
2740	Unpainted	2	0	0	43	0	80	76	95	82	98	100	95	100	100	100
2740	White	6	0	0	50	100	0	100	7	100	73	100	57	100	97	100

Legend: W - Weevils, includes rice and granary weevils and lesser grain borers.
BB - Branbugs, includes all other species.

Mortality of Introduced Insects Confined in Cages.

In order to obtain additional information on the effect of winter temperatures on insect populations in stored wheat, approximately 1600 insects, representing six common stored grain species, were placed in check capsules and put in the center of a 2740-bushel steel bin about six feet below the grain surface. The insects were confined in wire cages containing whole grain and flour. They were placed in the bin on November 15, 1943; removed at 15-day intervals for determining the rate of mortality; and the survivors replaced in the grain after each examination. The results of this experiment are presented in table 8.

It may be noted that a mortality of from eight to fifty percent occurred during the first two-week period. This may have been due to differences in moisture content of the grain in which the test insects were reared and that of the grain in the bin, since the temperature of both media was the same. By the first of February practically all of the lesser grain borers, rice weevils, and flat grain beetles were dead at which time the temperature of the grain at the point where the cages were located was 61 degrees F. By May 1, only one surviving sawtooth grain beetle was noted and on that date the grain temperature was 46 degrees F.

In comparing the rate of mortality in native and introduced insect populations as given in tables 7 and 8, it would appear that the native population was reduced more rapidly than the introduced population. Actually, the mortality rate was about the same for both groups. This can be explained by the fact that the native population was determined on the basis of an average sample from the bin under observations, whereas, the introduced insects were placed in the warmest part of the bin (center of grain mass).

Table 8: -- Mortality of caged stored grain insects placed in the center of a 2740-bushel bin, Hutchinson, Kansas, November 15, 1943 to May 1, 1944.

Date of removal	Percent mortality: Lesser grain borer	Rice weevil	Red flour beetle	Sawtooth grain beetle	Flat grain beetle	Longheaded flour beetle	Grain temperature Degrees F.
1943							
Dec. 1	47	24	12	52	50	8	77
Dec. 15	81	57	23	60	65	21	75
1944							
Jan. 1	89	63	39	69	91	26	71
Jan. 15	93	97	52	74	93	40	68
Feb. 1	94	100	65	77	94	62	61
Feb. 15	96		82	82	95	71	58
Mar. 1	97		96	86	95	86	56
Mar. 15	98		99	89	97	96	53
Apr. 1	99		100	93	100	100	50
Apr. 15	100			95			51
May 1				99.8*			46
Total number insects used	438	41	431	588	91	35	

* -- 1 specimen survived.

Study of Fluctuation of Insect Populations in Wheat Stored in Ever-Normal Granary Type Bins

During the past year the fluctuation of insect populations in wheat located in the upper southwest quadrant was studied from samples taken from center, south, southwest, and west portions and southwest surface of a series of steel and wood bins. In the 1000-bushel steel bins and the 1500-bushel wood bins a five-foot grain probe was used to sample the upper half of the bin while a seven-foot trier was used in 2740-bushel steel bins.

A total of 55 bins, including 24 1000-bushel steel bins, 28 2740-bushel steel bins and 3 wood bins, from the management series were used for this work. A record was made of the number of each species of insects taken from the five separate sampling locations for each examination. Near the beginning of the sampling period, June 10, 1943, samples were taken from the five locations in each bin and determinations made for fat acidity and germination. These tests were repeated for a similar set of samples taken January 1, 1944, (data not yet received).

A summary of the data obtained in this study are presented in tables 9, 10, and 11. Six species of stored grain insects were found in samples taken from this series of bins. However, the numbers of rice weevils and long-headed flour beetles are not included in the tables since their abundance was practically negligible. It may be observed from the tables that the flat grain beetle was taken in greater numbers than the other three species in steel bins. The maximum intensity of infestation in the wood bins was attained by the lesser grain borer with the red flour beetle ranking second.

The data indicate that the branbug populations reach their greatest intensity in August and September in steel bins but not until October and November in wood bins. The maximum population of the lesser grain borer occurs in October in both steel and wood bins.

Table 9:--Fluctuation of insect population in upper southwest quadrant of untreated wheat stored in 1000-bushel steel bins, Hutchinson, Kansas, May 10, 1943 to April 1, 1944.

Date of sampling	Average number of insects per 1000-gram sample per bin			
	Flat grain beetle	Sawtooth grain beetle	Red flour beetle	Lesser grain borer
1943				
May 10	0.9	0	0	0
June 10	0.7	0.7	0	0
July 1	4.0	1.7	0	0
July 15	10.3	5.2	0	0
Aug. 1	17.2	5.9	0.1	0.4
Aug. 16	21.2	3.6	0.5	1.1
Sept. 3	18.0	1.6	0.6	2.3
Sept. 16	11.3	0.7	0.8	3.4
Oct. 1	14.0	1.0	1.9	5.6
Oct. 30	5.4	0.5	0.9	1.4
Nov. 29	5.9	0.5	1.0	2.2
1944				
Jan. 1	2.2	0.3	0.1	1.2
Feb. 10	6.5	1.4	0	0.1
Apr. 1	0.8	0	0	0

Table 10;--Fluctuation of insect populations in upper southwest quadrant of untreated wheat stored in 2740-bushel steel bins, Hutchinson, Kansas, May 10, 1943 to April 1, 1944.

Date of sampling	Average number of insects per 1000-gram sample per bin: Flat grain beetle	Sawtooth grain beetle	Red flour beetle	Lesser grain borer
1943				
May 10	0.5	0.1	0	0
June 10	0.5	0.5	0	0
July 1	1.0	1.0	0	0
July 15	2.4	1.5	0	0
Aug. 1	6.0	6.7	0.1	0.7
Aug. 22 *	7.7	5.5	0.8	1.5
Sept. 16 **	5.4	10.3	1.4	6.0
Oct. 9 ***	8.3	0.0	1.0	10.0
Oct. 30	6.8	0.3	0	4.2
Nov. 29	4.7	0.4	0.1	3.1
1944				
Jan. 1	0.4	0.1	0	0.7
Feb. 10	0.4	0	0	0.1
Apr. 1	0.5	0.2	0	0

* - 4 bins fumigated after sampling and dropped from this analysis.
** - 3 bins fumigated after sampling and dropped from this analysis.
*** - 6 bins fumigated after sampling and dropped from this analysis.

Table 11:--Fluctuation of insect populations in upper southwest quadrant of untreated wheat stored in 1500-bushel wood bins, Hutchinson, Kansas, May 10, 1943 to April 1, 1944.

Date of sampling	Average number of insects per 1000-gram sample per bin: Flat grain beetle	Red flour beetle	Lesser grain borer
1943			
May 10	0.0	0.0	0.0
June 10	0.0	0.0	0.0
July 1	0.0	0.0	0.0
July 15	0.0	0.0	0.0
Aug. 5	0.7	0.0	0.2
Aug. 23	2.9	1.7	0.3
Sept. 16	1.0	2.7	1.0
Oct. 30	3.3	8.8	11.8
Nov. 29	6.1	4.8	7.4
1944			
Jan. 1	1.9	0.8	0.7
Feb. 10	0.8	0.0	0.0
Apr. 1	0.0	0.0	0.1

Control of Insects in Farm-Stored Grain

In cooperation with the Reno County Agricultural Conservation Committee, work has been initiated on the control of insects in farm-stored grain as outlined in the program of research for 1944. Farmers were found to be willing and anxious to cooperate in this project. They were unanimous in the opinion that there was a pressing need for information on the control of insects in farm-stored grain, especially in wooden farm granaries where the wood-boring species, such as the cadelle (Tenebroides mauritanicus L.), present a serious problem.

After making a survey of the many bins offered for this investigation, eight farms were selected as having granaries suitable for the proposed experimental work. A total of 20 empty wooden grain bins were thus made available for the projected treatments. The immediate objective was to apply various materials to the interior walls of wooden farm granaries in order to control existing infestations of the wood-boring species of stored grain insects and also to prevent re-infestation after the bins were filled with grain.

Preliminary tests of different materials in small model bins were made by Dr. R. T. Cotton at Manhattan, Kansas. As a result of these tests certain materials proved to be effective in preventing the cadelle from boring holes in the wood of the miniature bins. It was desired to test the efficiency of these and other promising materials under farm conditions. The various materials used in this work are listed below:

1. K1127 2(2(2,4,5,6,-tetrachlorophenoxy)ethoxy)ethyl chloride*
   (5% in deobase oil)

2. K208 phenothioxin* (5% in deobase oil)

3. K655 B(B(4-chlorophenoxy)ethoxy)ethyl chloride*
   (5% in deobase oil)

4. Deobase oil

5. Dormant tree oil spray. (recommended by Farrar, Flint, and Winburn for the treatment of wooden granaries.)

   Formula: Dendrol (dormant tree oil) . . . 1 gallon
   Lye. . . . . 3 ounces
   Water. . . . . 9 gallons

6. Termitox (pentachlorphenol) (20% in deobase oil.

7. DDT (dichloro-diphenyl trichloroethane) (6% in deobase oil).

Note: DDT was first dissolved in ethylene dichloride and the resulting solution added to the deobase oil.

8. Whitewash. Formula:

hydrated lime	50 pounds
casein glue	5 pounds
water to make desired consistency	

(Recommended in National Lime Association Bul. 304-D)

9. White lead paint. Formula:

white lead paste . . .	100 pounds
raw linseed oil. . . .	2 gallons
Japan drier.	1 pint
turpentine	1 pint
(stock paint)	

(Recommended in Farmers' Bulletin 1452)

For the first coat the stock paint was thinned with two-fifths its volume of turpentine; the second coat with two-fifths its volume of linseed oil. Naphtha was added in each instance to thin for use in a paint spray gun.

10. Red paint. Sherwin-Williams red paint No. 367.

Formula:

Venetian red	67%
Zinc oxide	4%
Magnesium sulfate.	29%

11. Sisalkraft paper lining.**

* - Materials supplied by the Dow Chemical Co.
** - Materials supplied by the Sisalkraft Co.

All of the liquid materials were applied to the bin walls with a paint spray gun at a pressure of 40 pounds. The compressed air fumigation apparatus was adapted for use in this work.

In order to evaluate the efficiency of the several materials used in treating the interior walls of wooden farm granaries, it was necessary to set up a method of determining the extent of damage by wood-boring species at the time the treatment was applied; and also to be able to detect any additional damage subsequent to the application of the treatment. To do this a vertical area one foot wide was marked off on the bin wall and horizontal lines at one-foot intervals were laid off beginning twelve inches above the floor and extending to the top of the bin wall. Thus, areas one foot square were delineated. The number of holes in each area were counted and recorded for each of the walls receiving different treatments with the exception of those walls which were sprayed with whitewash, white lead, and red paint. The whitewash and paints filled the holes sufficiently so that any new holes can be detected easily. The summary of the counts made in the above manner is given in table 12.

Table 12:--Extent of damage by wood-boring species of stored-grain insects to walls of wooden farm granaries, Reno County, Kansas, May, June, 1944.

Location	Height of bin wall (feet)	Number of sq. ft. counted	Number of holes per sq. ft.		
			Maximum	Minimum	Average
Bacon Farm SW bin	7	7	125	31	80
Bacon Farm SE bin	7	35	116	2	31
Oldenettel Farm	8	60	211	0	40
Gump Farm	6	6	27	3	10
Nicklaus Farm SE bin	11	22	121	0	29
Nicklaus Farm NE bin	11	22	64	0	18
Nicklaus Farm SW bin	11	22	81	0	16
Nicklaus Farm NW bin	11	22	15	0	7
Goodenough Farm	7	35	2	0	0.1
Swanson Farm E bin	6	24	127	0	31
Swanson Farm E boxcar	7	14	23	0	3
Swanson Farm W boxcar	7	7	36	0	15
Phillips Farm boxcar	7	28	123	0	28

The number of holes ranged from zero to 211 per square foot of wall area in those bins in which counts were made. No damage was observed to the floors. The amount of damage appears to be related to the level to which the bins had been filled in previous years, since the greatest concentration of holes followed rather definite contours along the bin walls.

No indication of the number of cadelles remaining in the bin walls could be obtained by inspection, although a number of both larvae and adults were observed while the bins were being prepared for treatment.

In order to determine any immediate effect of the various treatments, the bins were inspected a few days after the treatments were applied, and the comparative number of dead insects were noted. Few dead insects were found except in those bins which had been treated with DDT. In bins treated with this material there were large numbers of dead cadelle adults and larvae on the floors at the junction of the floor and wall. It is possible that other treatments killed the insects before they could emerge from their burrows and that DDT drives them out to die. The results with DDT were astonishing. Some 8,000 dead adults were swept up on the floor along 10 linear feet of wall space. The DDT evidently continued to kill for at least a month after application, since repeated inspection of treated bins revealed dying cadelles which had emerged from the walls.

It is of interest to note that several farmers in this vicinity have used whitewash as a wall treatment for farm granaries. In most cases the whitewash had scaled off in places leaving bare wood exposed. In all bins observed such unprotected areas were subject to attack by the cadelle, but wherever the whitewash was intact, no borings were found.

In the past is has been commonly recommended that granaries should be thoroughly cleaned before applying treatment. Since it is virtually impossible to remove all grain from cracks and crannies, it was decided to clean up some of the bins as well as possible and leave others in the condition they were found after the grain had been removed by the owner.

It was found that two coats of whitewash or paint were required to secure complete coverage and partial filling of the cadelle borings in the walls.

Most wooden farm granaries are rather loosely constructed making fumigation difficult. In order to make such bins reasonably gas tight, the walls of one bin on the Henderson farm were lined with sisalkraft paper. The other bin in this granary was left untreated. After filling with the present wheat crop it is planned to fumigate both bins to determine any differences in the dosage of fumigant required for successful fumigation.

Magnesium Oxide for Seed Treatment*

The recent increased interest in inert and chemical dusts for the protection of wheat from insect attack has led to the investigation of the insecticidal action of a number of materials both poisonous and non-poisonous. In previous reports from this laboratory the insecticidal properties of a number of disinfectant dusts have been given together with data on a number of other dusts not recommended as disinfectants but reported to be useful for protecting grain from insect damage.

The insect pests of stored grain feed on relatively dry foods and obtain much of their moisture requirements by breaking down or oxidizing these dry materials. The conservation of moisture is an important factor in their existence. It is thought that dusts cause the death of these insects by dehydration.

There are several theories to account for the desiccation caused by fine dusts coming in contact with the insect body.

1. Close contact of the dust with the insect body causes the body water to be conducted by capillary action to the air where it is evaporated. The drier the air, the faster the evaporation and consequently the more rapid the death of the insect.

2. By increasing the body surface of the insect, the evaporation surface is increased and desiccation results.

3. Insects have a "water proof" fatty film on their relatively pervious shell. Contact with hard, sharp, crystalline particles breaks the film. Drying of the insect naturally follows. Dusts of the diamond class of hardness (10 on the Moh scale) are most effective. They must have a hardness of at least 6.5 on the Moh scale to be effective. The dust must be fine with particles mostly under 10 mu. and a large proportion between 1 and 5 mu.

Many dusts are effective under dry atmospheric conditions and in previous tests, lime, sulphur, wood ashes, and even soy bean flour show good insecticidal value in 12% moisture wheat.

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* - Reported by R. T. Cotton and J. C. Frankenfeld.

Particle size of the dust would appear to be of considerable importance. In 1929 F. Zacher suggested the use of magnesium oxide against the granary weevil and other stored product pests such as Spermophagus subfasciatus, Dermestes murinus L. and Ephestia kuehniella. In the following year F. Zacher and G. Kunike reported the successful use of oxides and carbonates of magnesium, manganese, zinc and copper when in a fine dust. Compounds of silicon (such as sea sand) were also found effective when in a fine state. H. Schneider in 1932 reported good results with both magnesium oxide and magnesium hydroxide. H. Kreig in 1933 also reported on the insecticidal value of magnesium oxide. Low temperature and high humidity retard the action of these dusts.

In response to our request, Dr. R. C. Roark sent us a sample of magnesium oxide (ID No. 7363, No. 1) of which the surface-mean particle diameter was less than 0.25 micron. This is finer than the dust known as "Almicide".

Five-hundred gram samples of 12.5% moisture wheat in duplicate were treated with this dust at dosages of .05, 0.1, and 0.2 percent by weight. 200 rice weevil adults were added to each sample and to two untreated or check samples.

Thirteen days later the samples were examined with the following results:

Table 13: -- Effectiveness of MgO_2 in protecting 12.5% moisture wheat from rice weevil attack.

Sample number	Dosage magnesium oxide by weight	Condition of rice weevil 13 days after treatment: Number alive	Number dead
1	.05%	7	193
2	.05%	0	200
3	.1%	0	200
4	.1%	0	200
5	.2%	0	200
6	.2%	0	200
7	Check	197	3
8	Check	200	0

Two additional series of samples were prepared using the flour beetle, Tribolium confusum, and the lesser grain borer, as test insects. At the end of 5 days they were examined with the results shown in table 14.

Table 14: -- Effectiveness of MgO_2 in protecting 12.5% moisture wheat from the attack of the flour beetle and the lesser grain borer.

Lot No.	Dosage of MgO_2 by weight	Condition of insects after 5 days			
		Flour beetle		Lesser grain borer	
		No. alive	No. dead	No. alive	No. dead
1	0.05%	99	1	7	93
2	0.05%	65	35	0	100
3	0.1%	0	100	0	100
4	0.1%	0	100	0	100
5	0.2%	0	100	0	100
6	0.2%	0	100	0	100
7	Check untreated	100	0	100	0

As shown by the data of table 14 wheat treated with magnesium oxide at the rate of .1% by weight is quickly freed of all insect life. No emergence has been observed in the above samples.

The results of germination tests conducted with treated seed of 12.5% moisture content are given below.

Table 15: -- Effect of magnesium oxide treatment of 12.5% moisture wheat on viability.

Period of exposure	Treatment	Percent germination--Average of 2 tests
2 weeks	No treatment	93.5
do	.05% MgO_2	93
do	.1% MgO_2	95
do	.2% MgO_2	98
4 weeks	No treatment	87
do	.05% MgO_2	92
do	.1% MgO_2	90
do	.2% MgO_2	89

It is interesting to note from the above data that the germination of the treated seed is better than that of the untreated seed in nearly all cases.

To more fully evaluate the protective action of the dust, the tests were repeated with 14% and 16% moisture wheat. Results of these tests are given in table 16.

Table 16: -- Effectiveness of MgO_2 in protecting high moisture wheat from the attack of the rice weevil from May 18 to June 20, 1944. 100 adult rice weevil added to each 500 gram sample of wheat.

Lot No.	Moisture content of wheat	Treatment	Survival of rice weevil after 1 week	2 weeks	3 weeks	4 weeks	No. of progeny at end of 5 weeks
1	14%	.05% MgO_2	86	79	69	65	653
2	14%	.1% MgO_2	29	17	11	8	914
3	14%	.2% MgO_2	10	6	3	1	876
4	14%	Untreated	98	98	95	90	546
5	16%	.05% MgO_2	94	91	83	81	585
6	16%	.1% MgO_2	82	66	55	41	226
7	16%	.2% MgO_2	74	51	40	21	157
8	16%	Untreated	100	95	94	88	854

From the data of table 16 it is evident that as the moisture content of the wheat increases the effectiveness of the dust decreases, and that with wheat of 14% moisture or above the material is not effective. Fourteen percent is the upper moisture limit at which wheat can be safely stored, and most seeds are stored with a moisture content considerably lower than that.

Germination tests were conducted with treated 14% moisture wheat with the results shown in table 17.

Table 17: -- Effect of magnesium oxide treatment of 14% moisture wheat on viability.

Period of exposure	Treatment	Percent germination--Average of 2 tests
4 weeks	No treatment	88
do	.05% MgO_2	88
do	.1% MgO_2	90
do	.2% MgO_2	93

As was the case with the 12.5% moisture wheat, the viability of the 14% moisture wheat was improved in most cases by the treatment with magnesium oxide.

Tests with "Almicide" for the Protection of Rough Rice*

With the cooperation of Dr. E. C. Tullis, Pathologist of the U. S. Dept. of Agriculture, stationed at Beaumont, Texas, tests were conducted to determine the efficacy of Almicide in protecting rough rice from infestation by insects.

One-pound samples of rough rice in quadruplicate were treated with Almicide at the rate of .1%, .2%, and .275% by weight. The samples in small burlap bags were placed in a rice mill in Beaumont, Texas, on November 29th, together with 4 bags of untreated rice. They were all exposed to insect infestation until the following April 11th at which time they were removed and shipped to Manhattan for examination.

When examined on June 20th the number of living insects per sample were recorded with the results shown in table 18.

Table 18: -- Development of insect infestation in 1-pound samples of rough rice after exposure to infestation in rice mill from November 29, 1943 to April 11, 1944.

Sample number	Treatment	No. of living insects--Average of 4 samples: Rice weevil	Red flour beetle	Granary weevil	Lesser grain beetle	Flat grain beetle	Sawtooth grain beetle
1	Untreated	580	18	12	15	6	20
2	.1% by wt. Almicide	3	2	0	1	0	0
3	.2% do	0	0	0	0	0	0
4	.275% do	0	0	0	0	0	0

From the data of table 18 it is evident that Almicide affords excellent protection to rough rice at all dosages tried. In the samples that were treated at a dosage of .1% by weight a few living insects were present but no appreciable damage had been caused and the number of insects present was negligible. In the samples treated at the heavier dosages no insects were present. The untreated rice was heavily infested.

* - Reported by R. T. Cotton and J. C. Frankenfeld.

Effect of Common Grain Fumigants on Baking Qualities*

Little information is available with regard to the effect of grain fumigants on the baking quality of flour made from fumigated grain. Since carbon tetrachloride and related chlorides are currently being evaluated as grain fumigants it was felt desirable to investigate their effect on baking quality, and since mixtures of carbon tetrachloride and carbon disulphide are so commonly used, carbon disulphide alone and in combination with carbon tetrachloride was included in the tests.

Ten pounds samples of wheat were fumigated in tightly stoppered glass flasks for a period of 1 week with dosages of the various fumigants of 50 lbs. per 1,000 bushels. This dosage represents the highest concentration that would be used under ordinary circumstances and is somewhat higher than would normally be used.

After fumigation, the various samples were allowed to aerate for two weeks. They were then milled and loaves baked from the resulting flours. A second series of samples will be allowed to aerate for two months after which they will be milled and a second baking made.

Results of the baking tests are shown in table 19.

The data of table 19 indicates that there is little effect on baking values as a result of fumigation with most of the fumigants tried. Carbon tetrachloride alone caused a significant loss in loaf volume and tetrachloroethylene imparted a slight odor. These effects were probably caused by retention of the fumigants by the flours. With longer aeration of the fumigated wheat these effects will probably disappear. Milling and baking of the second series of samples will settle this point.

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* - Reported by R. T. Cotton and J. C. Frankenfeld in cooperation with Milling Department of Kansas State College.

Table 19:--Baking values of flour from wheat fumigated with various fumigants for one week and aerated for 2 weeks before milling.*

Sample number	Fumigant used	Dosage Pounds per M bushels	Protein %	Ash %	Moisture %	Mixing time Min.	Loaf vol. cc	Texture	Color	Remarks
1	Untreated check		10.90	.390	15.10	3.5	755	82-o	82cy	No objectionable odor
2	Carbon disulphide	50	11.	.375	14.70	3.5	750	82-o	82cy	do
3	Carbon tetrachloride	50	11.30	.405	14.25	3.5	685	82-o	82cy	do
4	Trichloroethylene	50	11.15	.398	14.70	3.5	755	82-o	80cy	do
5	Carbon disulphide-CCl_4 (1-4) mixture	50	11.30	.398	14.35	3.5	760	82-o	82cy	do
6	Tetrachlcroethylene	50	10.20		14.26	3.5	730	87-o	grey	Slight odor

* - Average of two tests.

Effect of Nitriles on the Baking and Milling Qualities of Wheat*

It has previously been reported that fumigation of wheat with a 1-18-1 mixture of acrylonitrile, carbon tetrachloride and trichloroacetonitrile caused a deleterious effect upon the baking quality of flour made from fumigated wheat. These tests were made one week after fumigation. Additional tests were made two months later after the wheat had had an opportunity to become aerated. As indicated by the data of tale 20 the baking values of the treated wheats appeared to have been recovered.

Table 20: -- Effect of fumigation with 1-18-1 mixture of acrylonitrile + carbon tetrachloride + trichloroacetonitrile on baking quality of wheat.

Sample number	Treatment	Time of baking (after fum.)	Mixing time	Absorption	Loaf vol. cc	Crumb color	Grain texture	Remarks
1	2 gals.per M. bu.	1 week	3.7	66	773	80cy	80-o	No odor
2	Check	1 week	3.0	66	945	83cy	84-o	do
3	2 gals.per M. bu.	2 months	3.3	65	713	82cy	83-c	do
4	Check	2 months	3.3	65	680	81cy	80-o	do
5	1 gal. per M. bu.	1 week	3.4	66	775	80cy	78-o	do
6	Check	1 week	3.2	66	895	80cy	82-o	do
7	1½ gals.per M. bu.	2 months	3.3	65	708	81cy	80-o	do
8	Check	2 months	3.3	65	705	81cy	80-o	do

As a further check on the ability of the grain to recover from the effects of fumigation with the 1-18-1 mixture, a sample of wheat was fumigated for 1 week with a dosage of 2 gallons of the mixture per 1,000 bushels and allowed to aerate for 2 months. At the end of that period the grain was milled and baked with the results shown in table 21.

Table 21:--Effect of 1-18-1 mixture of acrylonitrile-carbon tetrachloride and trichloroacetonitrile on baking quality of wheat.

Sample number	Dosage per M. bushels	Aeration period	Mixing time	Loaf vol. cc	Crumb color	Remarks
1	2 gals.	2 months	2.8	800	83cy	No odor
2	Check	2 months	2.8	845	83cy	do

From the above data it is evident that in this latter case the bad effects of the fumigant mixture (loss in loaf volume) were not overcome by aeration for a two-month's period. It is doubtful whether this mixture will be satisfactory as a fumigant for wheat intended for milling and baking.

* - Reported by R. T. Cotton and J. C. Frankenfeld in cooperation with the Milling Department of Kansas State College.

Reproduction of Granary and Rice Weevil in 12, 13, and 14% Moisture Wheat and Corn at 65° F.*

In the last report we presented data relative to the survival of the granary and rice weevil at a constant temperature of 65° F. Due to the fact that emergence of progeny was not completed at that date, this information could not be included. Tables 22, 23, 24, and 25 give the biweekly reproduction at 65° F. in 12, 13, and 14% wheat of the granary and rice weevil.

In this series of tests, 50 adults instead of 100 were used in each lot. The reproduction in number of adults used is due to the fact that smaller quantities of wheat (100 grams) had to be used, owing to limited refrigerator space.

Reproduction occurred in all three moisture variant lots, and in both wheat and corn. As observed at higher temperatures, the rate of reproduction is influenced by the moisture content of the food, increasing as the moisture content is increased. This relationship holds true for both the granary and rice weevil, when reared in wheat or corn.

Development of larval stages of both the rice weevil and granary weevil is extremely slow at 65° F. so that in order to complete our records in a reasonable time, samples of grain exposed to oviposition by the weevils were removed at biweekly intervals and placed in incubators with a constant temperature of 80° F. and a relative humidity of from 70 to 80%. At a constant temperature of 65° F. the minimum development period of the rice weevil and granary weevil from egg to adult was observed to be 3 months.

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* - Reported by R. T. Cotton and J. C. Frankenfeld.

Table 22: -- Summary of reproduction of granary weevil in 12, 13, and 14% moisture wheat at 65° F.

Moisture content of	Number of progeny produced during: 1st, 2nd and 3rd week	4th & 5th week	6th & 7th week	8th & 9th week	10th & 11th week	12th & 13th week	14th & 15th week	16th & 17th week	18th & 19th week	Total
Wheat I										
12%	43	3	0	2	0	7	63	45	0	163
13%	39	0	0	0	7	0	51	52	42	191
14%	85	18	6	143	30	55	141	89	57	624
Wheat II										
12%	41	0	3	5	23	20	64	21	23	200
13%	155	0	0	5	6	23	95	87	0	371
14%	146	8	2	12	11	25	121	103	2	430

Table 23: -- Summary of reproduction of granary weevil in 12, 13, and 14% moisture corn at 65° F.

Moisture content of	Number of progeny produced during: 1st, 2nd and 3rd week	4th & 5th week	6th & 7th week	8th & 9th week	10th & 11th week	12th & 13th week	14th & 15th week	16th & 17th week	18th & 19th week	Total
Corn I										
12%	1	0	0	1	1	18	16	17	17	71
13%	10	0	0	0	1	2	10	38	19	80
14%	25	1	0	3	3	18	31	40	23	144
Corn II										
12%	1	0	0	0	1	9	17	25	3	56
13%	30	0	0	1	0	32	25	46	16	150
14%	34	0	0	0	1	18	56	54	27	190

Table 24: -- Summary of reproduction of rice weevil in 12, 13, and 14% moisture wheat at 65° F.

Moisture content of	Number of progeny produced during: 1st, 2nd and 3rd week	4th & 5th week	6th & 7th week	8th & 9th week	10th & 11th week	12th & 13th week	14th & 15th week	16th & 17th week	18th & 19th week	Total
Wheat I										
12%	611	282	201	240	141	96	81	6	0	1682
13%	623	532	233	464	382	237	244	170	83	2668
14%	690	447	425	493	493	396	481	346	229	4000
Wheat II										
12%	373	112	202	210	186	55	48	0	0	1186
13%	633	328	443	425	375	152	126	88	50	2620
14%	749	453	667	577	346	338	413	216	160	3914

Table 25: -- Summary of reproduction of rice weevil in 12, 13, and 14% moisture corn at 65° F.

Moisture content of	Number of progeny produced during: 1st, 2nd and 3rd week	4th & 5th week	6th & 7th week	8th & 9th week	10th & 11th week	12th & 13th week	14th & 15th week	16th & 17th week	18th & 19th week	Total
Corn I										
12%	229	145	75	48	13	71	8	5	0	594
13%	206	143	121	42	5	93	9	32	7	658
14%	131	219	137	98	50	139	35	32	2	843
Corn II										
12%	117	95	52	52	21	48	15	1	0	401
13%	145	112	82	42	10	62	10	20	6	487
14%	209	119	144	74	40	87	34	24	14	745

Effect of Temperature and Moisture Content of Wheat upon the Survival and Reproduction of the Granary and Rice Weevil*

Continuing our investigations on the effect of temperature and moisture upon the granary and rice weevil, we have inaugurated a series of tests at a constant temperature of 90° F., in which the moisture content of the wheat varies, at 1% intervals, from 9 to 14% inclusive. This series has been in progress for eleven weeks and the percentages of survival are summarized in table 26. Two replicate lots of 100 adults of each species are included in each of the moisture variant wheat series.

In general, as in previous tests, at lower temperatures, longevity of the adult weevils increases as the moisture content of the wheat is increased. A constant temperature of 90° F. is not conducive to longevity. The granary weevil appears to be longer lived than the rice weevil at this temperature.

Reproduction records for this series are not complete and will be included in a later report.

* - Reported by R. T. Cotton and J. C. Frankenfeld.

Table 26: -- Survival of granary and rice weevil adults in 9, 10, 11, 12, 13, and 14% moisture wheat at 90° F.

Insect used	Percentage of survival after					
	1 Week	3 Weeks	5 Weeks	7 Weeks	9 Weeks	11 Weeks
9% Wheat						
Granary weevil	67	13	5	0		
do	54	20	6	0		
Rice weevil	27	4	0			
do	8	1	0			
10% Wheat						
Granary weevil	92	85	38	3	0	
do	90	79	41	18	6	
Rice weevil	79	65	11	7	0	
do	52	28	16	11	3	0
11% Wheat						
Granary weevil	95	85	68	23	12	0
do	97	94	82	52	29	0
Rice weevil	94	89	70	49	32	23
do	72	57	45	39	30	22
12% Wheat						
Granary weevil	94	89	79	66	38	29
do	100	90	82	71	50	44
Rice weevil	100	95	85	74	43	25
do	93	84	79	64	45	30
13% Wheat						
Granary weevil	99	97	91	82	73	60
do	97	92	86	76	63	58
Rice weevil	99	96	63	59	22	15
do	98	88	15	15	13	7
14% Wheat						
Granary weevil	99	90	78	72	66	55
do	100	91	84	72	63	54
Rice weevil	99	95	61	54	49	42
do	100	78	12	11	9	7

Effect of the Amount of Dockage on the Ability of T. confusum to Survive and Reproduce in Wheat of Various Moisture Content*

In Report No. 11 observations on this series of tests were reported covering the first five weeks that the tests were in progress. This report takes up the records beginning with the sixth week.

As previously reported two sets of tests, one at a constant temperature of 85° F. and the other at 90° F., were established in continuing our investigations on the effect of dockage on the ability of T. confusum to survive and reproduce in wheat. Tables 27 and 28 summarize the percentage of survival at weekly intervals, and the total number of progeny recovered for a period of 19 weeks.

With the exception of the 9% moisture wheat series, there is very little difference in the percentage of survival due to the amount of dockage present. In the 9% wheat, however, the percentage of survival increases with increased amounts of dockage. There is, however, a decided increase in the percentage of survival between the different moisture-levels. Although this species is able to feed on practically moisture-free food, yet over extended periods of time a higher percentage of survival is obtained with a food of higher moisture content. The apparent decrease in survival as noted in the 8% dockage lots in both the 12 and 15% moisture series is not readily explainable. Undoubtedly some other factor is involved than those under control in these tests.

From the standpoint of reproduction, we have the same picture as was obtained in our earlier tests, i.e., as the percentage of dockage is increased, the total number of progeny produced and able to complete development, increases. Also, as the moisture content of the rearing media is increased, the total number of progeny increases.

At 90° F. the percentage of survival likewise increases as the moisture content of the wheat is increased. Dockage, except in the 9% series, again having little or no effect on survival. Reproduction at all moisture levels increases as the amount of dockage present in the wheat is increased, and at a given dockage rate, increases as the moisture content of the wheat is increased.

Although the percentage of survival is slightly lower in the 90° F. series as compared with the 85° F., the total number of progeny is in general consistently higher in the 90° F. series. This is particularly true in the lots containing the larger percentages of dockage.

In the lots containing 1, 2, and 4% dockage in the 12% moisture series run at 90° F., the records are not complete. In these three lots, all of the adults had died after the 4th week. These lots were therefore restocked after the 4th week and will be carried on until they have reached the 19th week limit. There is no logical explanation for the high mortality noted above.

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* - Reported by R. T. Cotton and J. C. Frankenfeld.

Table 27: -- Survival of T. confusum in 9, 12, and 15% moisture wheat with varying amounts of dockage at 90° F.

Rearing media	Percentage of survival after: 6 Weeks	7 weeks	8 weeks	9 weeks	10 weeks	11 weeks	12 weeks	13 weeks	14 weeks	15 weeks	16 weeks	17 weeks	18 weeks	19 weeks	Total No. progeny
9% Wheat															
Clean wheat berries	49	38	25	17	6	2	0	0	0	0	0	0	0	0	0
Same plus 0.5% dockage	86	83	74	46	24	14	10	8	6	4	2	1	1	0	10
Same plus 1.0% dockage	87	87	87	82	77	68	58	36	25	18	13	10	7	7	54
Same plus 2.0% dockage	92	92	92	92	90	88	85	83	69	57	44	34	25	24	212
Same plus 4.0% dockage	94	91	87	85	80	76	73	69	64	59	56	49	45	41	447
Same plus 8.0% dockage	94	93	89	85	83	80	75	69	65	55	48	38	33	28	884
12% Wheat															
Clean wheat berries	69	69	69	69	68	68	68	66	61	54	47	40	31	22	84
Same plus 0.5% dockage	36	33	33	33	33	33	33	33	33	33	33	30	26	23	307
Same plus 1.0% dockage	99	99	99	99	97	92	87	80	75	51	44				297
Same plus 2.0% dockage	97	97	97	97	97	96	91	91	87	77	61				427
Same plus 4.0% dockage	93	93	93	91	90	90	90	89	86	83	81				679
Same plus 8.0% dockage	98	96	96	96	96	95	93	92	91	83	82	76	74	70	1911
15% Wheat															
Clean wheat berries	86	84	83	83	83	83	83	83	83	83	82	81	80	75	358
Same plus 0.5% dockage	91	91	91	90	89	89	89	89	88	87	87	87	87	87	738
Same plus 1.0% dockage	94	94	94	93	93	93	92	91	90	88	88	87	85	84	931
Same plus 2.0% dockage	93	93	93	93	93	92	92	91	90	85	85	84	84	82	1202
Same plus 4.0% dockage	98	97	96	95	94	93	93	91	91	91	91	90	89	89	1704
Same plus 8.0% dockage	95	94	94	94	93	92	92	88	84	78	74	72	71	71	1824

Table 28: -- Survival of *T. confusum* in 9, 12, and 15% moisture wheat with varying amounts of dockage at 85° F.

Rearing media	Percentage of survival after: 6 Weeks	7 weeks	8 weeks	9 weeks	10 weeks	11 weeks	12 weeks	13 weeks	14 weeks	15 weeks	16 weeks	17 weeks	18 weeks	19 weeks	Total No. progeny
9% Wheat															
Clean wheat berries	50	40	29	19	15	10	10	8	8	5	5	4	3	3	1
Same plus 0.5% dockage	92	92	90	84	76	71	66	57	49	40	30	21	16	9	32
Same plus 1.0% dockage	85	85	85	83	81	71	66	57	52	39	34	24	16	15	134
Same plus 2.0% dockage	86	86	83	79	77	75	70	61	56	50	40	37	30	23	213
Same plus 4.0% dockage	90	90	83	80	77	76	70	63	60	54	51	36	29	25	398
Same plus 8.0% dockage	52	49	47	45	45	44	43	41	35	35	33	28	27	27	725
12% Wheat															
Clean wheat berries	89	89	89	88	88	88	85	81	80	77	71	66	61	59	122
Same plus 0.5% dockage	93	92	92	92	91	87	86	83	81	79	78	76	75	72	353
Same plus 1.0% dockage	94	93	92	83	81	78	75	75	73	68	66	66	59	57	507
Same plus 2.0% dockage	92	91	90	85	84	81	81	80	77	77	75	74	72	70	630
Same plus 4.0% dockage	83	79	78	76	75	71	68	66	65	65	63	60	58	56	791
Same plus 8.0% dockage	39	38	37	37	37	37	33	33	31	29	28	27	26	24	502
15% Wheat															
Clean wheat berries	95	95	95	95	95	95	95	95	94	94	94	94	94	91	367
Same plus 0.5% dockage	92	91	91	90	90	89	89	89	89	89	89	87	87	86	532
Same plus 1.0% dockage	96	96	96	96	96	96	96	94	94	91	90	90	90	90	686
Same plus 2.0% dockage	93	93	93	93	93	93	93	93	93	93	93	93	91	91	968
Same plus 4.0% dockage	94	94	94	94	93	93	91	91	90	90	90	90	90	88	1051
Same plus 8.0% dockage	90	87	86	86	86	85	69	68	66	66	66	66	65	65	1346